RESULTS OF CROPPING SYSTEMS RESEARCH CONDUCTED IN SOUTH CENTRAL MONTANA-2016

Southern Agricultural Research Center, Huntley, MT

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1. Project Name: Foliar applications to correct micro-nutrient deficiencies in wheat

2. Investigators:
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3. Justification: We summarized 23 soil tests representing 14,000 acres in Stillwater County. Zinc (Zn) soil test levels averaged 0.33 ppm which is within the responsive range for fertilizer addition (Table 1). Soil test for copper (Cu) averaged 0.67 ppm, a level just above the threshold for response according to MSU recommendations. Soil tests for iron (Fe) indicated that iron levels were < 5.0 ppm 21% of the time. For these reports soil manganese (Mn) levels were well within recommended soil test levels.

   Most experts recommend soil based fertilizer either broadcast, or banded with the seed as the best way to manage micro-nutrient deficiencies. But it can be argued that soil based methods are less efficient than foliar applications. And for nutrients such as boron (B), and copper, the difference between deficiency and toxicity is too narrow to warrant fertilizer application to mineral soils. With soil test levels of 2 of 4 micro-nutrients at or near the threshold for response, and a third (iron) highly variable across the region, a foliar based maintenance application of micro-nutrients could be warranted. Local experience with this management approach has convinced some area producers that this practice pays for itself. But without a replicated trial these claims cannot be confirmed.

4. Objectives: Evaluate response of wheat to foliar applied micro-nutrient fertilizer in a wheat/fallow and a continuous crop system grown in soils that are near or within the responsive range for fertilizer recommendations.

5. Methods: We obtained the commercial micronutrient fertilizer “Micro 500” produced by AgroLiquid, St. Johns, MI. The analysis was 0.02% boron, 0.25% copper, 0.37% iron, 1.20% manganese, and 1.80% zinc derived from sodium borate, copper sulfate, ferrous sulfate, manganese sulfate, and zinc sulfate respectively. The local recommendation for this product (AgroLiquid) is 1 to 2 quarts/acre typically added to the broadleaf weed herbicide mix and co-applied. Based on the soil sample summary we targeted zinc as the most likely nutrient to be limiting. The 1 quart/acre rate of the Micro 500 is equivalent to 0.044 lbs Zn/a. Using a zinc only product derived from zinc sulfate a 2nd treatment was designed matching the lbs/a rate of Zn provided by the Micro 500. A third and fourth treatment were created by doubling the rate of each product. A final fifth treatment (0 rate) was included as a check plot. Treatments were arranged in a randomized complete block with 4 replications. Plot size was 8 feet wide by 15

feet long. There were 5 locations. Two spring wheat plots near Rapelje were placed in adjacent fields where the primary difference was the preceding crop. One previous crop was fallow while the other was spring pea. Two locations near Broadview were on winter wheat following fallow. A fifth location was near Ft. Smith on spring wheat following sunflower. Treatments were foliar applied just after jointing using the product mixed in water and hand sprayed with an 8 ft boom at a rate of 14 gal/a. Approximately 2 weeks later flag leaf samples were collected after flag leaves were fully extended. These tissue samples were analyzed for nutrient content by Agvise Laboratories, Northwood, ND. Near the end of July plots were harvested using a small plot combine to harvest a 4.5 ft wide swath through the center of each plot when grain was mature. Grain samples were processed at SARC for moisture, test weight, and protein. Grain yields were standardized to 13% moisture.

6. Results: Sites were chosen based on grower input of the history of field level soil test values and their perception of sandy, low organic matter locations. Composite soil samples (0 to 6 in depth) were collected to confirm actual nutrient levels (Table 2) although results were not received prior to layout of experimental plots. Comparing actual soil test values for each location with literature values (Table 1) for expected response showed that 2 of the 5 sites might be expected to respond to zinc applications. All sites tested below the threshold for boron and copper response and were considered likely for a positive response to fertilization from treatments 1 and 2.

   The 1-2 quart/acre recommendation from AgroLiquid was based largely on what producers were willing to pay. The 1 quart rate cost approximately $5/acre for the product and by adding this to the broadleaf herbicide mix, there was no additional cost for this fertilizer application. The 2 quart rate would be $10/acre.

   Statistical analysis showed no significant response for any measured variable and no significant interaction of site by treatment. Combining analysis across 5 locations still showed no significant interaction of treatment or site by treatment, although there were some significant differences across sites as expected. Tables 3 through 10 present all the data for yield, test weight, protein, and tissue concentrations of boron, manganese, iron, zinc, and copper.

   There are some soils in SC Montana that are clearly deficient in micro-nutrient concentrations for boron and copper (Table 2) and may be borderline for zinc as indicated by tissue concentrations (Table 6). These results indicate this particular commercial product at these rates failed to provide that response. The research question now becomes a rate question for foliar applications. Further, can soil applied micro-nutrients be managed to address deficiencies? And finally since wheat yield levels are moderate under dryland conditions, micro-nutrient responses might better be expected in higher yielding (irrigated) environments. Further research may provide answers to these questions for small grain producers.

Table 1. Critical minimum threshold levels (ppm) for micro-nutrients where a positive yield response is expected to nutrient applications is expected.

Nutrient	Soil test value*	Tissue test value**
Zn	0.5	15-20
Fe	5	50
Mn	1	10-20
Cu	0.5	3-5
B	1	10

* Fertilizer Guidelines for Montana Crops. Montana State University Extension Publications EB-161, March 2005.

** Nutrient Deficiencies & Toxicities in Crop Plants. The American Phytopathological Society, 3rd printing, 1996.

Table 2. Soil test values for each location of foliar nutrient application study, SC Montana, 2016.

Soil Test	Broadview (Ferds)	Broadview (Stiles)	Rapelje (following peas)	Rapelje (following wheat)	Ft Smith	units
pH	7.7	6.5	8.0	7.7	6.7	-log[H+]
N	2	4	11	11	17	ppm
P	6	20	16	20	31	ppm
K	258	194	405	435	376	ppm
Zn	2.0	0.7	1.0	2.5	1.4	ppm
Fe	6.2	18.2	7.4	7.0	15.2	ppm
Mn	7.8	5.8	4.6	3.7	14.9	ppm
Cu	0.5	0.4	0.5	0.5	1.5	ppm
B	0.6	0.3	0.6	0.6	0.6	ppm
CEC	22	10	26	19	26	meq/100g
OM	2.5	1.2	2.0	2.1	2.5	%

Table 3. Wheat grain yield (bu/a) for micronutrient foliar applications at five locations, SC Montana, 2016.

Treatment	Broadview (Ferds)	Broadview (Stiles)	Rapelje (following peas)	Rapelje (following wheat)	Ft Smith	Mean over locations
Variety	Yellowstone	Clearstone	WB9879CLP	WB9879CLP	Vida	
Control	43.0	44.3	32.5	29.2	17.3	33.26
Mix 1 qt/a	39.1	41.6	34.9	29.5	15.7	32.14
Mix 2 qt/a	44.6	49.3	31.6	29.9	17.7	34.62
Zn 1 qt/a eq	39.3	48.4	32.4	30.6	18.4	33.81
Zn 2 qt/a eq	38.6	43.2	32.6	30.2	15.7	32.08
LSD(.05)	NS	NS	NS	NS	NS	NS

NS = non significant

Table 4. Wheat grain protein (%) for micronutrient foliar applications at five locations, SC Montana, 2016.

Treatment	Broadview (Ferds)	Broadview (Stiles)	Rapelje (following peas)	Rapelje (following wheat)	Ft Smith	Mean over locations
Variety	Yellowstone	Clearstone	WB9879CLP	WB9879CLP	Vida	
Control	6.2	9.3	13.2	14.6	20.0	12.65
Mix 1 qt/a	8.2	9.9	12.9	14.9	19.8	13.13
Mix 2 qt/a	8.4	9.3	13.0	14.9	19.5	13.00
Zn 1 qt/a eq	8.3	9.3	13.3	14.9	19.4	13.04
Zn 2 qt/a eq	8.0	10.3	12.7	15.0	19.9	13.16
LSD(.05)	NS	NS	NS	NS	NS	NS

NS = non significant

Table 5. Wheat grain test weight (lbs/bu) for micronutrient foliar applications at five locations, SC Montana, 2016.

Treatment	Broadview (Ferds)	Broadview (Stiles)	Rapelje (following peas)	Rapelje (following wheat)	Ft Smith	Mean over locations
Variety	Yellowstone	Clearstone	WB9879CLP	WB9879CLP	Vida	
Control	6.2	62.3	61.7	60.4	52.0	59.49
Mix 1 qt/a	58.8	60.3	62.5	59.5	52.3	58.66
Mix 2 qt/a	61.2	61.3	61.8	59.6	51.5	59.07
Zn 1 qt/a eq	59.1	61.1	62.2	59.7	52.3	58.86
Zn 2 qt/a eq	59.8	60.1	62.2	59.2	51.5	58.55
LSD(.05)	NS	NS	NS	NS	NS	NS

NS = non significant

Table 6. Flag leaf tissue Zn concentration (ppm) for micronutrient foliar applications at five locations, SC Montana, 2016.

Treatment	Broadview (Ferds)	Broadview (Stiles)	Rapelje (following peas)	Rapelje (following wheat)	Ft Smith	Mean over locations
Variety	Yellowstone	Clearstone	WB9879CLP	WB9879CLP	Vida	
Control	6.5	7.3	15.5	14.3	25.0	13.7
Mix 1 qt/a	6.8	7.5	16.0	15.5	30.0	15.2
Mix 2 qt/a	7.8	8.5	16.3	15.8	24.5	14.6
Zn 1 qt/a eq	7.0	7.8	16.8	15.5	25.0	14.4
Zn 2 qt/a eq	8.8	7.5	15.8	15.0	23.5	14.1
LSD(.05)	NS	NS	NS	NS	NS	NS

NS = non significant

Table 7. Flag leaf tissue B concentration (ppm) for micronutrient foliar applications at five locations, SC Montana, 2016.

Treatment	Broadview (Ferds)	Broadview (Stiles)	Rapelje (following peas)	Rapelje (following wheat)	Ft Smith	Mean over locations
Variety	Yellowstone	Clearstone	WB9879CLP	WB9879CLP	Vida	
Control	11.0	11.8	5.8	5.8	8.0	8.45
Mix 1 qt/a	13.5	10.5	5.8	6.5	7.8	8.80
Mix 2 qt/a	14.3	11.0	6.8	6.8	9.0	9.55
Zn 1 qt/a eq	14.0	11.5	6.0	5.8	9.8	9.40
Zn 2 qt/a eq	13.5	10.0	5.5	6.0	7.5	8.50
LSD(.05)	NS	NS	NS	NS	NS	NS

NS = non significant

Table 8. Flag leaf tissue Fe (ppm) concentration for micronutrient foliar applications at five locations, SC Montana, 2016.

Treatment	Broadview (Ferds)	Broadview (Stiles)	Rapelje (following peas)	Rapelje (following wheat)	Ft Smith	Mean over locations
Variety	Yellowstone	Clearstone	WB9879CLP	WB9879CLP	Vida	
Control	69.8	77.0	55.8	65.3	72.0	67.95
Mix 1 qt/a	68.3	80.0	53.8	66.3	81.0	69.85
Mix 2 qt/a	72.0	75.8	56.3	67.5	65.3	67.35
Zn 1 qt/a eq	74.0	75.8	53.8	63.8	66.3	66.7
Zn 2 qt/a eq	72.5	80.3	56.3	67.8	64.3	68.2
LSD(.05)	NS	NS	NS	NS	NS	NS

NS = non significant

Table 9. Flag leaf tissue Mn concentration (ppm) for micronutrient foliar applications at five locations, SC Montana, 2016.

Treatment	Broadview (Ferds)	Broadview (Stiles)	Rapelje (following peas)	Rapelje (following wheat)	Ft Smith	Mean over locations
Variety	Yellowstone	Clearstone	WB9879CLP	WB9879CLP	Vida	
Control	28.5	21.0	30.1	35.8	60.0	35.20
Mix 1 qt/a	22.0	21.8	30.0	37.5	57.3	33.70
Mix 2 qt/a	26.8	20.0	29.5	40.0	60.0	35.25
Zn 1 qt/a eq	24.3	20.8	27.3	37.3	59.8	33.85
Zn 2 qt/a eq	29.5	20.0	29.8	38.0	56.0	34.65
LSD(.05)	NS	NS	NS	NS	NS	NS

NS = non significant

Table 10. Flag leaf tissue Cu concentration (ppm) for micronutrient foliar applications at five locations, SC Montana, 2016.

Treatment	Broadview (Ferds)	Broadview (Stiles)	Rapelje (following peas)	Rapelje (following wheat)	Ft Smith	Mean over locations
Variety	Yellowstone	Clearstone	WB9879CLP	WB9879CLP	Vida	
Control	3.3	1.25	5.0	4.5	8.5	4.50
Mix 1 qt/a	3.3	1.25	5.0	4.8	7.8	4.40
Mix 2 qt/a	3.3	1.25	5.3	5.0	7.5	4.45
Zn 1 qt/a eq	2.8	1.25	5.3	4.3	8.8	4.45
Zn 2 qt/a eq	3.3	1.75	4.8	4.8	7.8	4.45
LSD(.05)	NS	NS	NS	NS	NS	NS

NS = non significant